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Art. XXII.—*Notes on the so-called Obsidian from Geelong and from Taradale, and on Australites.*

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Introduction.

In the Records of the Geological Survey of Victoria, Vol. III., Part 3, 1914, pp. 322-326, recently published, Mr. E. J. Dunn, F.G.S., in a paper entitled "Further notes on Australites," quotes some old analyses of Mr. Cosmo Newbery of two specimens of "obsidian" from the Geelong district, of a "basalt" from near Kyneton, and of an australite from the Wimmera Plains. In addition a recent analysis of a so-called obsidian from Taradale is quoted, and the claim is made in the paper that these analyses show that acidic volcanic glass, similar in composition to that of australites exists in Victoria associated with the newer volcanic rocks.

Mr. Dunn's long and wide experience as a field geologist ensures that any paper of his dealing with problems of field geology will command confidence and respect from all geologists. He has had, however, no special experience in chemical and petrological questions, and the problems raised in his recent paper and on australites generally are to a large extent chemical and petrological. In consequence of this I feel that he has misunderstood the evidence and come to erroneous conclusions.

The object of this communication is to criticise some of the evidence stated in Mr. Dunn's paper and to show that the older rock analyses of the Geological Survey of Victoria, in common with many old rock analyses, are quite unreliable, that the rocks from Geelong, described as obsidian, are really tachylyte, that the rock from Taradale is not obsidian, but a volcanic glass of peculiar composition and belonging to the Intermediate division, that no rock of the nature of obsidian is known to occur among the newer volcanic rocks of Victoria, and that in consequence no support is lent to the hypothesis of the volcanic origin of australites by an appeal to the chemical composition of the newer volcanic rocks of this State.

The nature of obsidian.

During the last century the significance of many of the terms used by the older mineralogists and geologists has by a process of evolution undergone change and revision. The change has usually been from a vague and general definition to one of a more precise and limited character. The progressive changes in the meaning attached to the word obsidian illustrate this process.

A century ago, and even down to 60 or 70 years ago, the black compact glass called obsidian was believed to be definite in composition and to constitute a true mineral species.

Later it was shown to be a volcanic glass of variable composition, and then any volcanic glass was spoken of as obsidian. At a later date the glassy form of basalt was distinguished by the name of tachylyte, while the name of obsidian was reserved for volcanic glasses of acid to intermediate composition.

In recent years intermediate volcanic glasses have been distinguished either as trachyte-glass and andesite-glass, or as trachytic-obsidian and andesitic-obsidian, while the term obsidian, without qualification, has been by petrologists restricted to the acid volcanic glasses corresponding in chemical composition to the rhyolites and acid granites.

It is this modern definition as an acid volcanic glass which alone should be applied to obsidian, and it is in this sense that I, in common with other petrologists, understand the term.

The present-day definition implies an acid volcanic glass of about the following composition :—

SiO_2	= 66–80%
Al_2O_3	= 13–16%
Fe_2O_3, FeO	2 – 3%
CaO, MgO	1 – 3%
K_2O, Na_2O	6 – 8%

Most obsidians have a silica percentage of over 70, and it should be noted not only that the iron oxides seldom exceed 3 per cent., but that the alkalies are commonly in notable excess over the alkaline earths.

The so-called obsidians from Geelong.

In the Notes on the Physical Geography, Geology and Mineralogy of Victoria, by A. R. Selwyn and G. H. F. Ulrich, published in the Intercolonial Exhibition Essays, 1866, p. 65, obsidian is stated to occur in a basalt quarry near Geelong in patches and irregular veins of an inch or more in thickness. Two analyses by Mr. Cosmo Newbery are quoted from this locality. The same statements and analyses are quoted in Selwyn's Descriptive Catalogue of the rock specimens and minerals in the National Museum, collected by the Geological Survey of Victoria, 1868, p. 80. The specimens are labelled Specimen 24 and 24a.

These are two of the analyses quoted by Mr. Dunn, and are as follow :—

	Geelong Specimen. Black to brown. Sp. Gr. 2.41. No. 24.	Geelong Specimen. Bluish grey. Sp. Gr. 2.36. No. 24a.
SiO_2	72.23	68.45
Al_2O_3	16.43	5.38
Fe_2O_3	2.28	7.21
CaO	3.17	8.11
MgO	2.12	1.03
MnO_2	—	0.50
TiO_2	—	0.30
Na_2O, K_2O	4.65	7.36
Loss by ignition	0.13	—
	101.01	98.34

To anyone accustomed to rock analyses the above figures at once suggest inaccuracy, not only by the summation, but still more by the curious and unusual proportions of some of the oxides.

Mr. Dunn has overlooked the fact that as long ago as 1898 Mr. Walcott[1] in his paper on Obsidianites had examined these specimens, had called attention to the discrepancy between the published analyses and the appearances of the specimens and had detached a chip from specimen 24 and by chemical analysis obtained only 53.2 per cent. of silica. He pointed out that the appearance and silica percentage pointed to the material being tachylyte and not obsidian.

1 Proc. Roy. Soc. Victoria, vol. xi. (N.S.), 1898, p. 32.

By the courtesy of Professor Spencer I was enabled to make an examination of the two specimens, Nos. 24 and 24A. There are two specimens of No. 24. The smaller is partly scoriaceous, partly dense, and is a dark grey-green in colour.

The larger specimen is similar to the smaller, but shows a sporadic development of spherical scoriaceous areas constituting pseudo-spherulites. The rest of the material is a dense glass.

No. 24A is dense and mostly dark blue in colour. Some black spherulitic areas occur with cracks, filled with brown limonite.

Both 24 and 24A have all the appearances characteristic of tachylyte, as Mr. Walcott has previously described. I determined the specific gravity of the two pieces of No. 24 by Walker's balance. The small piece gave a value of 2.36.

The specific gravity is, of course, quite unreliable, as the specimen is very vesicular. The true specific gravity would be much higher.

The larger piece of 24 gave a value of 2.50.

This specimen is also vesicular, so the result is also too low. A small chip from the larger specimen of No. 24 was fairly compact, but contained some vesicles. By the Joly's spring balance the specific gravity of the chip was determined at 2.60.

We may conclude that the true specific gravity exceeds this latter figure. The glass must therefore be basic in composition, i.e., the specimen is tachylyte. This is in agreement with Mr. Walcott's silica determination of 53.2 %

Specimen No. 24A ("Blue obsidian") is larger and quite compact. By Walker's balance the specific gravity is 2.74. This also indicates clearly that the specimen is tachylyte. I am quite at a loss to explain how Mr. Cosmo Newbery could have obtained the results quoted for the chemical analysis of these specimens or the figures for their specific gravities (No. 24 = 2.41, No. 24A = 2.36). It is clear, however, from Mr. Walcott's work and my own determinations of specific gravity that both specimens are tachylyte and not obsidian, as described.

Further, it is unfortunately clear that the older chemical analyses of rocks, etc., published by the Geological Survey of Victoria, must be regarded as quite untrustworthy.

This criticism must include in this connection not only the analysis of the "obsidian" from Geelong, but also the analysis of Specimen No. 21, an australite from Horsham, in which less than 5 per cent. of alumina is recorded, and over 10 per cent. of alkalies, and also the "basalt" from the Coliban River, near Kyneton, in which 61.96 % of silica, 10.43 % of iron, and only 2.10 % of alkalies are recorded. These are published in the essay cited above, and are quoted without comment by Mr. Dunn. They must be regarded as quite unreliable.

The Taradale "obsidian."

Associated with pebbles of black basalt along the course of the Coliban River from the Upper Coliban Reservoir to Taradale, Mr. Dunn found and has described[1] well-rounded pebbles of what he calls black obsidian. Mr. Dunn first found these pebbles at Taradale. He quotes a first-class analysis made of this material by Mr. J. C. Watson, of the Geological Survey Laboratory, and for comparison the analysis by Mr. J. C. Mingaye, of N.S. Wales Geol. Laboratory, of a remarkable australite from Uralla, in N.S. Wales.

The analyses are as follow, with another for comparison :—

	(1) Taradale Obsidian.	(2) Uralla Australite.	(3) Diorite Porphyry.
SiO_2	63.67	64.68	62 18
Al_2O_3	15.83	16.80	15.77
Fe_2O_3	1.39	6.57	1.83
FeO	4.06	1.01	2 44
MgO	2.15	2.50	3.55
CaO	3.88	3.88	4.13
Na_2O	3.57	tr.	3.92
K_2O	3.69	4.01	3.91
H_2O+	0.02	—	0.70
H_2O-	0.15	—	0.30
TiO_2	1.27	—	0.55
P_2O_5	0.02	—	0.32
MnO	0.43	—	BaO 0.43
NiO and CoO	0.01	—	—
Total	=100.14	99.45	100.23
Sp. Gr.	= 2.569		

3. Diorite Porphyry, Steam Boat, Little Belt Mt., Montana. Analyst, W. F. Hillebrand. Described by L. V. Pirrson. Recorded in Chemical Analyses of Igneous Rocks by Washington, 1903, p. 222, United States Geol. Survey.

The Taradale rock is a remarkable one, and Mr. Dunn has done a distinct service to Victorian petrology in drawing attention to it, since it appears to be a type hitherto unrecognised among the recent

1. Op. cit.

volcanic rocks of Victoria. Until it has been found "in situ," and its relation to the basaltic rocks of the district has been determined it would be premature to give a detailed discussion of its characters.

A glance at the analysis, however, shows at once that it is not obsidian, as the relatively low silica percentage and the six per cent. of alkaline earths preclude this possibility. On the other hand it is clearly not a basalt in view of the high silica percentage, and the fact that the total alkalies exceed 7 per cent.

Through Mr. Herman, Director of the Geological Survey of Victoria, I obtained a small fragment of the material, from which the analysis was made, and had two rock sections made. The rock is clearly a volcanic glass and contains besides brown glass, globulites, trichites and scattered phenocrysts of olivine, augite and plagioclase felspar.

The minerals present show affinities with the basalts, but the large amount of glass is evidently high in silica and the alkalies.

It has long been known that in a molten basic magma in which crystals are floating the composition of the molten ground mass is generally more acid than that of the phenocrysts or of the whole rock. In Teall's British Petrography, pp. 399-401, analyses by Lagorio are quoted which show this effect, which is especially marked in rocks of intermediate composition and less marked in basic rocks. It is interesting to note that the glass of such rocks is richer in silica and in the alkalies than is the parent rock. It is this richness in silica and the alkalies which makes the Taradale rock interesting, and suggests that it may represent the glass from a basaltic magma from which the bulk of the phenocrysts are wanting.

The closest approach to the composition of the Taradale rock is an analysis of a diorite-porphyry from Montana, quoted above.

The norms of the Taradale rock and of the Montana rock, and of the Uralla australite are as follow :—

	Taradale Rock.	Diorite Porphyry.		Uralla Australite.
Quartz	15.66	11.2		37.2
Orthoclase	21.68	22.8		23.9
Albite	30.39	33.0		—
Anorthite	16.12	13.9		19.2
Diopside	2.51	5.3	Corundum	5.4
Hypersthene	9.06	8.1		6.2
Magnetite	2.09	2.6		3.9
Ilmenite	2.43	1.1	Hematite	3.8

In the American classification both rocks belong to—

Class 2. Dosalane.

Order 4. Dofelic.

Rang 2. Domalkalic.

Sug-Rang 3. Sodipotassic.

Their magmatic name is Adamellose.

This comparison shows that in chemical composition the Taradale rock belongs to the basic end of the intermediate class, while the mineral phenocrysts and apparently its field occurrence suggest a genetic relationship with the basalts. It is quite clear that the rock is not obsidian.

This analysis of the evidence of the so-called obsidian from Geelong and from Taradale shows that Mr. Dunn's claim that acidic volcanic glass, similar in composition to that of australites, exists in Victoria associated with the newer volcanic rocks, is quite unwarranted by the evidence so far available.

The chemical characters of australites.

The literature on australites, obsidianites, or obsidian buttons as they were formerly called, is now voluminous. The best papers describing the physical characters of these bodies are Mr. Walcott's[1] and Mr. Dunn's.[2]

The illustrations in Mr. Dunn's paper are particularly valuable. From the point of view of origin and chemical relationships the most important papers are by Dr. Summers[3] and Dr. Suess.[4] Dr. Summers has given the most complete discussion of their origin from a chemical standpoint, and has given a fairly complete bibliography of the literature, which it is unnecessary for me to repeat.

Among the hypotheses as to the origin of australites are the following :—

1. That they are artificial bodies.
2. That they have been formed by lightning discharge during dust storms.
3. That they are of volcanic origin.
4. That they are of meteoritic origin.

For the first two hypotheses no serious evidence or arguments have been advanced.

1. Walcott. Proc. Roy. Soc. Victoria, vol. xi., (n.s.), 1898.
2. Dunn. Records Geol. Surv. Victoria, vol. ii., pt. iv., 1908. Bulletin Geol. Surv. Vict., No. 27, 1912.
3. Summers. Proc. Roy. Soc. Victoria, vol. xxi. (n.s.), pt. ii., 1909; Aust. Assoc. Adv. Sc., Melb., 1913.
4. Suess. Jahr. d. k.k. Geol Leichaust. Vienna, vol. 50, 1900, p. 194.

The volcanic hypothesis was once commonly held until the examination of recent volcanic rocks in Australasia and the absence of similar forms from any known active volcanoes made the explanation of their composition and distribution difficult.

Dr. Summers has clearly pointed out that though these bodies have been called obsidianites, the material is not obsidian, and differs from it in certain notable chemical characters, especially the low alkali percentage, and the relatively high percentage of the alkaline earths, the latter being normally in excess of the former, whereas the reverse relation is true of obsidian.

Comparison of the Taradale so-called obsidian with the Uralla australite.

Mr. Dunn has made a comparison of the chemical composition of the Taradale rock with that of the Uralla australite, and comes to the conclusion that the two rocks are practically identical and both are obsidian. I have shown that the Taradale rock is not obsidian, neither for that matter is the Uralla australite. Neither are the two rocks identical. It is true that the percentages of silica alumina and alkaline earths are fairly comparable, but the percentages of soda and of oxide of iron, especially ferric oxide, are widely different.

Two ways exist of comparing analyses, each of which is more illuminating than a simple comparison of oxides. The one method is by a comparison of the norms determined on the American classification. These are shown above (p. 338), and show wide differences.

The other method is by the drawing and examination of "variation curves," as utilised by Dr. Summers in his recent paper.[1] By this method variations of composition within the limits of a rock species can be shown to lie along a curve, and not only so, but where a number of different rocks in a district have a genetic relationship with one another this is brought out clearly by the fact that all the related types conform to the curves. On the other hand if two or more rocks are not so related this difference is indicated by a lack of conformity between the curves representing the different rocks.

I have made such a comparison of "variation curves" between the curves of the Uralla australite and that of the Taradale rock

1. Op. cit.

The Uralla australite while quite extreme in chemical composition is shown by Dr. Summers to lie on a curve containing most of the australites which have been analysed. In the case of the Taradale rock the points for ferrous oxide, soda and total alkalies lie a long way outside the main curve of most of the australites.

The comparison of the two types by both methods, therefore, indicates their essential dissimilarity and the dissimilarity between the Taradale rock and australites in general.

Incidentally it may be noted that Mr. Dunn's comparison of the Taradale rock is not with Victorian australites, as one would expect, but with a New South Wales australite of quite extreme composition. This is curious since Mr. Dunn's claim is to establish a connection between australites and Victorian volcanic rocks. Of course a comparison with analyses of Victorian australites would have at once shown an almost complete dissimilarity of composition.

The complete failure up to the present of all attempts to locate any newer volcanic rocks in Victoria, or even in Australasia, which are similar in chemical composition to the australites, is a formidable difficulty in the way of the acceptance of a volcanic origin for these bodies. With the large and rapid increase of our knowledge of the newer volcanic rocks of Australasia, made in recent years, the probability of finding rocks of such peculiar composition becomes less and less, and the argument, though based on negative evidence, that the australites are not of volcanic origin has been proportionately strengthened.

Even if a volcanic rock of similar composition to that of the australites were found in Australia, the difficulties of the distribution of these bodies, in many cases hundreds of miles from any volcanic rocks, remains as has been pointed out by Dr. Summers. The shapes of these bodies, and especially the smooth nature of the flange, appear to me to negative Mr. Dunn's ingenious hypothesis that they represent the blebs of volcanic bubbles, a hypothesis put forward by Mr. Dunn to explain not only their form, but also their distribution.

It is the general failure of the volcanic hypothesis rather than positive evidence in favour of an extra-terrestrial origin which leads most modern writers on this subject to regard the meteoritic hypothesis of the origin of australites as the most probable one in view of the present state of our knowledge on the subject.